ment of Agriculture Agricultural Research Service Vol. 35, No. 2, February 1987

Agricultural Research

Cockroach Territory

Story on page 6

Reporting Science: Whose Responsibility?

Ours is a problem-solving agency, and I know how essential it is to communicate the answers we find, not just to other scientists, but to the farmers and ranchers and business people who can make use of the information. In the Agricultural Research Service, we are as committed to reporting our research findings as we are to conducting the research itself.

There are many audiences for our research information, and we try to reach them in different ways.

- Scientists within the agency publish some 4,000 papers and other publications each year on their research findings. These are usually directed to other scientists in similar fields of research.
- Each year, we summarize some 1,500 technical abstracts of ARS research and add them to a computerized information service called the TEKTRAN (Technology Transfer Automated Retrieval System).

This system is used by USDA's Extension Service and other agencies as well as a growing number of private firms and organizations.

- Each year some 50 ARS scientists obtain government patents on their discoveries—now available in most cases for use by industry on an exclusive basis. Information about patents appears in the *Federal Register*, in a newsletter published by the Commerce Department called *Government Inventions for Licensing*, and in this magazine.
- Individual scientists at our 130 locations nationwide are urged to maintain industry and press contacts. They are encouraged to seek out the farm and trade press and should keep reporters and editors posted on what they are doing.
- Within ARS, professional information work is carried out by a relatively small staff of writers, editors, and photographers who have a special interest in science. It is not their task to compete with the news media, but rather to assist media people to locate good stories among our vast and often confusing research output.

To help accomplish this, the ARS information staff issues press releases to the print media, distributes 5 radio interviews with scientists each week, and produces some 20 television news segments every year. We also take interested reporters on tours of research projects.

- We introduce our findings to writers and editors who may not be familiar with our agency or understand the impact of agricultural research on the lives of typical Americans. Twice a year, an information staffer visits more than 30 major media outlets in New York City with reports and photos of newsmaking research.
- The information staff reports new research findings on a quarterly basis to the House and Senate Appropriations Committees and to other congressional committees. Each Quarterly Report is mailed to more than 1,000 farm editors, trade journals, and newspaper and magazine science writers. A condensed version of the report is sent to the chief executive officers of many of the nation's agribusinesses.
- Finally, we publish an annual research progress report, circulated to hundreds of research directors.

Now to the question posed above: Whose responsibility to report research? To me there is no question that all employees of our agency bear responsibility for communicating research findings to as many segments of the public as possible—to the scientific community, to research users, and to the general reader who is simply curious about what is going on in the world. In ARS, information is everybody's business.

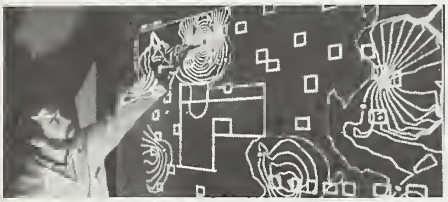
In conclusion, I think most of us in the scientific community are doing a better job today of reporting science to the public through the media than we ever have before. And we have more opportunities. At least 66 newspapers now devote a section to science each week. There are also relatively new magazines, like *Omni* and *Discover*, that offer good markets for science news. Further, the quality of science reporting has improved immensely over the past few decades, spurred by the advent of the atomic age and the space age and the age of medical miracles.

Without doubt, more doors are open today than ever before for the scientific organization with a sincere desire to communicate its research to the public.

Terry B. Kinney, Jr. Administrator

Agricultural Research

Cover: Richard Brenner, an ARS entomologist, observes video projection of contour lines that show the distribution of Asian cockroaches in an infested yard near Lakeland, FL. Brenner, Richard Patterson, and colleagues study feeding and migration habits to develop possible control measures. Story begins on page 6.
Photo: Tim McCabe.
(1286X1364–8)



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Old Wheat Seed Invites Fungus

Wheat seed held over the first planting season after harvest and used in later years is increasingly vulnerable to a fungus-caused root disease.

Only 35 to 50 percent of such seed will germinate if planted during a wet fall in soil infected by *Pythium* fungus.

This discovery by one of the world's top authorities on soilborne fungus diseases of wheat is significant because popular new seed varieties create pressure for seed dealers to store older, less popular varieties for years.

As a result of his research on old seed, R. James Cook, a USDA Agricultural Research Service plant pathologist at Pullman, WA, says the seed industry is now literally cleaning house. One Pacific Northwest seed dealer discounted sales of $250,000 worth of 4- and 5-year-old seed after evaluating Cook's findings.

James Cook inspects laboratory-grown *Pythium*, a soil-living fungus that attacks the roots of wheat plants. (1085X1142-31)

"Under late-fall conditions of severe *Pythium* infestation, the difference between the old and new seed that actually grows into plants is like night and day," says Cook. Old seed sometimes produces yields that are 10 to 25 percent less than those of new seed.

However, it is still desirable to use 1- or 2-year-old seed to avoid problems with seed dormancy, Cook says. Dormancy is a built-in mechanism that prevents new seed from germinating when planted in August and early September into warm, fallow soil. Since these conditions also limit *Pythium*, it is safe to use older, more vulnerable seed, Cook says.

It's especially important to plant new wheat seed in the higher rainfall, annually cropped areas of the Pacific Northwest. Farmers there often seed wheat in late September and October into heavy surface residues typical of conservation tillage systems.

It was Cook who first identified the fungus *Pythium* in 1979 as a chief cause of stunted growth and poor yields in wheat grown under conservation tillage. This system of minimum soil preparation leaves more straw on the soil surface than conventional tillage. He says residues like straw slow water runoff and soil erosion, but "they also create a breeding ground for disease."

Cook speculates that the greater damage to plants produced with old seed results from the seedlings being less vigorous. He says old seed also leak more nutrients than fresh seed, which stimulates the growth of *Pythium* in the soil.

According to Cook's results, treating old seed with fungicides helps. But even the best treatments applied to older seed are inferior to using new seed.

Cook says normal tests for seed germination do not tell the whole story. "Old seed may do well in the lab, but if it's vulnerable to *Pythium*, look out!"—By **Howard Sherman,** ARS.

R. James Cook is in USDA-ARS Root Disease and Biological Control Research, Washington State University, 219 Agricultural Sciences Bldg., Pullman, WA 99164. ■

Popcorn Scent May Sell More Rice

The addition of a popcornlike aroma to unscented American rice might sell more of this surplus commodity at home and overseas.

Ronald G. Buttery of the USDA Agricultural Research Service center in Albany, CA, says that with further research and development, a fragrance-imparting chemical could soon be added to unscented domestic rice during milling. The chemical that provides the popcorn scent, 2-acetyl-1-pyrroline, was first isolated, identified, and synthesized in 1983 by Buttery's team in Albany and by colleagues at the International Rice Research Institute in the Philippines.

Much of the world's rice crop has a natural popcorn scent. "In the Middle East, India, Pakistan, the Philippines, Thailand, Indonesia, and Malaysia, many people would rather eat aromatic rices than the common varieties," Buttery says, adding that "the aromatic rice that is probably the most familiar to Americans is Basmati—the kind you can get in Indian restaurants."

During taste tests in the Albany laboratory, a 22-member panel judged the aroma of a typical American rice to which the fragrance chemical had been added and found it nearly matched the naturally scented varieties.

Using two laboratory procedures—capillary gas chromatography and mass spectrometry—Buttery and colleagues isolated the chemical responsible for the aroma in naturally scented rice. Although other scientists had previ-

ously identified more than 100 other compounds rice emits when it is cooked, no single compound had the unmistakable popcornlike scent of the expensive aromatic rice varieties.

Buttery's research team also recently developed a rapid method to determine the amount of fragrance chemical in different rices. This laboratory test should aid researchers trying to cross hardy varieties of American rice with scented kinds.

Aromatic rice is typically more expensive and harder to grow than the unscented varieties.—By **Marcia Wood,** ARS

Ronald G. Buttery is at the USDA-ARS Western Research Center, 800 Buchanan Street, Albany, CA 94710. ■

Barley Survives on Less Water

Spring barley that grows on less than a third of normal irrigation water yet still produces about half the normal yield will soon be available for conservation planting.

Because it adapts to growing conditions throughout the West, it should help save soil in at least 12 states.

"If we can get barley growing on abandoned farms and disturbed lands, we can halt the invasion of weeds and reduce wind and water erosion. When farmers and ranchers want to plant other crops such as range grasses, they can seed them the year after the barley has stabilized the soil. This barley will also provide cover and feed for wildlife," says Robert T. Ramage, a USDA Agricultural Research Service geneticist in Tucson, AZ.

"Most farmers and ranchers won't find this barley suitable for grain production. While the barley thrives on less water, reduced yield would make it uneconomical. Farmers often need maximum yield just to break even," Ramage says.

Ability to grow relatively fast on scarce precipitation is not new in the plant kingdom. Many weeds and desert plants do just that and usually invade abandoned and disturbed areas. But Ramage's new barley out competes most weeds.

It has produced grain yields of 2,500 to 3,500 pounds per acre in Arizona desert when the soil was irrigated with 6 to 8 inches of water before planting. When grown without any irrigation, relying on the 2 to 6 inches of normal precipitation during the winter growing season, the barley yielded 500 to 3,000 pounds. Normal farm yields in Arizona are around 6,000 pounds using 30 to 36 inches of irrigation water.

The new barley flourishes where conventional barley withers and dies because its root system is different. In 15 years of research, Ramage managed to change the normal shallow, spread-out root system to one that grows down 6 feet or more to suck up water.

This barley will be jointly released this winter through ARS, the University of Arizona's Agricultural Experiment Station, and USDA's Soil Conservation Service. Commercial producers will increase seed supplies, and growers should get the new barley in about 2 years.—By **Dennis Senft,** ARS.

Robert T. Ramage is in USDA-ARS Barley Genetics and Breeding Research, 2000 East Allen Rd., Tucson, AZ 85719. ■

Switchgrass Spurs Beef Gain

A small improvement in digestibility of a forage grass is more profitable to beef producers than an increase in yield, says a USDA-Agricultural Research Service scientist at Lincoln, NE.

Kenneth P. Vogel, a plant geneticist, says that a 6-percent increase in digestibility bred into Trailblazer, a new switchgrass variety, accounted for a 23-percent gain in beef production per acre. That increase in gain was worth about $35 per acre to beef producers at 1986 prices.

"Just a slight change in digestibility can greatly improve animal performance," Vogel says. "And we proved that it's possible to gain digestibility without decreasing forage yield."

In Nebraska, breeder Kenneth Vogel checks seed production of his new Trailblazer switchgrass. (0985X1043-28)

Switchgrass, a native of the American tall grass prairie, thrives during the hot summer months when other grasses tend to slow growth. If not grazed, it grows to 5 or 6 feet tall.

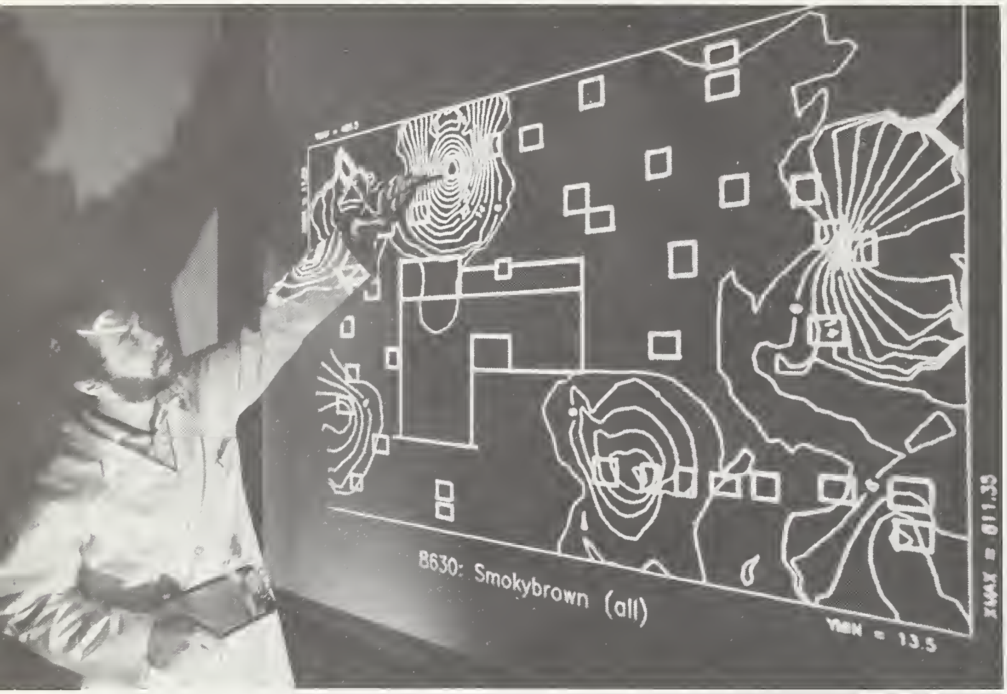
In 3 years of grazing trials at Mead, NE, yearling cattle on Trailblazer for 60 days had an average gain per acre of 306 pounds compared with 227 for cattle grazing Pathfinder, a commonly grown switchgrass.

The new variety was developed by Vogel, ARS geneticist Herman J. Gorz, and geneticist Francis A. Haskins, of the University of Nebraska at Lincoln.

Trailblazer was released as a new variety in 1984, and certified seed was available for commercial plantings in 1986.—By **Linda Cooke,** ARS.

Kenneth P. Vogel is in USDA-ARS Forage and Range Research, Room 332 Keim Hall, East Campus, University of Nebraska, Lincoln, NE 68583. ■

Cockroaches on the Move



Tim McCabe

Barry Fitzgerald

Top: Richard Brenner studies diagram of a house and yard near Gainesville, FL, showing the distribution of tree-living cockroaches. Large rectangles at left represent the house, smaller squares are trees, and contour lines show the roaches' travel from their principal habitat. In this test area, entry into the home was made from the tree nearest the back porch, where a dish of dog food is kept for the owner's pet. (1286X1364-27)

Above: Newly arrived in the United States, the Asian cockroach has established a sizable beachhead in central Florida. (0786X906-18)

Cockroaches. The very word brings to mind images of nasty little insects scurrying under a refrigerator to escape a lethal blow from a rolled-up newspaper, a chemical spray, or the sneaker sole that squashes.

Yes, roaches move to avoid immediate danger. They also move across miles by ship, automobile, and airplane, spreading to uninfested areas; and they move through an unseen dimension—time, ever adapting to unfavorable conditions.

The German roach—a type many city dwellers know well—is famous for its adaptability to chemicals; each time a new one is developed, this roach changes genetically to resist it. It has adapted so well that it can thrive on soap, bookbinding glue, paper, and wood.

Of the 4,000 species of cockroach known to scientists, only 50 annoy people. But that's enough to prompt consumers to spend $2 billion annually to stop the roach dead in its tracks.

Richard S. Patterson and Richard J. Brenner, entomologists for USDA's Agricultural Research Service in Gainesville, FL, hope that by tracking the roach's movements, they might learn how to stop it.

The most recent, and perhaps disturbing, roach movement that Brenner and Patterson have studied is that of the newly arrived Asian roach, known in scientific circles as *Blattella asahinai*. This roach hitched a ride, probably on importers' ships, all the way from Southeast Asia to the coast of Florida. Ever since it moved in, the scientists have been working with University of Florida's Phil Koehler to get a handle on our new guest's lifestyle, likes, and dislikes.

They have found that the new roach, which looks almost exactly like the German, lives in woods, fallen leaves, and people's lawns. It isn't afraid of light like the German cockroach, though; in fact, it is attracted to brightly colored surfaces. Its period of frenzied activity occurs just after sunset. Worse yet, it flies. All of this means that the unsuspecting family watching television could be visited by these 1/2-inch-long critters, which might fly in and choose the screen or a white wall as a landing site.

Already, the roach has traveled throughout at least 400 to 500 square miles of central Florida. The scientists think it can survive weather conditions in areas as far north as Maryland, though they can't guess when it will make it that far. Mostly, it gets around by hitching rides on cars leaving an infested area.

In fact, Brenner and technician Kristin T. Williams have to check their clothes and cars carefully when leaving an infested study site. "We don't want to make it worse," he says.

Although ARS studies show that all registered roach insecticides kill the Asian roach, the scientists fear that in time it will develop the same resistance its German relatives have.

The Gainesville scientists also work on controlling the roaches that moved into people's homes long ago—the German and brownbanded—as well as those that live mainly outdoors, like the American, Australian, and smokybrown.

One chemical they have studied—hydroprene—acts as a birth control for roaches. It is a synthetic copy of a roach-produced growth regulator that keeps a roach juvenile, preventing sex-

ual maturity. Normally, a roach stops producing the regulator and moves into adulthood.

"The roach gets two signals, one for adulthood and this one, which tells it to stay juvenile. It has characteristics of each but ends up sterile, which is what we want," Patterson says.

The Asian cockroach has already infested 400 to 500 square miles of central Florida since arriving in the United States.

Hydroprene, available in commercial products for home use, is 100 percent effective if applied right. But since it doesn't actually kill roaches, adults still have to be dealt with.

For control of brownbanded and German cockroaches, the scientists recommend first reducing the population with a spray. Then, says Brenner, to get the ones that resist the insecticide, or that moved out of the spray area because they sensed it, "you use a bait trap, which has a food attractant to get them back and a stomach toxin to kill them."

Next comes an application of hydroprene to decrease population potential. The ones that survive the spray and bait can't reproduce.

Lastly, the scientists say, glue traps like the Roach Motel are used to monitor roach numbers. ARS studies show that for every roach trapped in 24 hours, there are 600 to 800 unseen. Previously, people thought that for every one caught, there were 99. "This indicates that sighting even one roach in that 24-hour period likely warrants reapplying control measures," Brenner says.

The scientists have other promising ideas that haven't hit the market yet.

The first is a new toxic bait that works exceptionally well for the large species of roaches like American, Australian, and smokybrown. Brenner found that these roaches like distiller's grain, a granular byproduct of alcohol production. He put it with commercially available insecticides and found that he could knock off entire populations.

Roach and Human Hormones Similar

Hormones that control the way you digest your food may have a strong evolutionary link to a newly discovered natural hormone that affects the common cockroach's digestive system.

ARS researchers Ronald J. Nachman, William F. Haddon, and G. Mark Holman, along with colleague Nicholas Ling of The Salk Institute (La Jolla, CA) reported in the journal *Science* that the cockroach chemical is "strikingly similar" to the important gastrin II and cholecystokinin hormones, or neuropeptides, in humans.

The cockroach material, which the team has named leucosulfakinin, is a neuropeptide—a material that delivers messages from the nervous system to other parts of the body.

Although chemical similarities among humans and other forms of life are not unusual, what makes the team's discovery unique is that leucosulfakinin has the highest correlation yet reported between a neurohormone in a vertebrate (backboned animals such as humans) and that in an insect.

The findings should be of interest to medical researchers studying the two human neuropeptides as well as to scientists investigating molecular evolution—a theory that evolution occurs at the molecular level.

Nachman and Holman are pursuing cockroach neuropeptides as possible models for a new generation of safer, more powerful insecticides that might kill roaches by exaggerating or blocking the natural activity of the roach chemicals.—By **Marcia Wood,** ARS.

Ronald J. Nachman and William F. Haddon are at the USDA-ARS Western Research Center, 800 Buchanan St., Albany, CA. G. Mark Holman is at the USDA-ARS Veterinary Toxicology and Entomology Laboratory, P.O. Drawer GE, College Station, TX 77841. ■

"The best part is that animals don't like the attractant, so the bait is safe to use."

Another development, for German cockroaches only, doesn't kill them or stop reproduction; rather, it repels.

Repellents being explored by commercial companies could decrease the spread of German cockroaches, Patterson says. They could be sprayed in shipping containers and grocery bags, which harbor roaches and serve to transport them across miles.

For every roach caught in a household glue trap, there are probably 600 to 800 nearby, ARS studies show.

A homeowner could keep them out of key places with repellents. "Computers, microwave ovens, and other electronic gear provide the ideal warm, dark refuges in which roaches live and breed," says Patterson. And since roaches can damage equipment, keeping them out could avoid expensive repairs.

Patterson has also studied a natural control agent that attacks the roach during the one time in its life when it can't move—as an egg. The agent is a tiny wasp that parasitizes the eggs, and when used with baits, gets rid of 95 to 98 percent of the roach population.

The wasp works for all roaches but the German type, which protects its offspring by carrying its egg case until baby roaches hatch.

About the size of a pinhead, the wasp lays its own eggs inside a roach egg. When wasp larvae emerge, they feed on developing roaches. "They're so small that people probably wouldn't even see them in their homes," Patterson says, "and of course they don't hurt the environment."

Patterson thinks the wasp has a future with commercial roach control companies.

The Gainesville entomologists not only explore and evaluate control methods, they also plot roach movement.

In so doing, Brenner found that the larger roaches (often called palmetto

Barry Fitzgerald

To study the distribution and population size of Asian cockroaches in the Tampa, FL, area, Richard Brenner and Jemy Hinton, Hillsborough County (FL) cooperative extension agent, count roaches collected in sticky traps during a single night around this residence. (0786X902-27A)

bugs or waterbugs) do not prefer people's homes as living quarters, as was once thought.

They'd rather live in a tree hole, a palm tree canopy, and less commonly, in certain kinds of mulch.

They move into a home only when the tree hole becomes cramped or food becomes scarce. The most accessible opening is usually an air vent leading directly to an attic, where they'll set up housekeeping.

Barry Fitzgerald

Above: Richard Patterson and Richard Brenner discovered that large roaches live primarily in tree holes by coding roaches trapped outdoors with a series of colored stripes and releasing them. They were later recaptured most often in traps near tree holes. (0786X904-27)

It is usually after the attic also gets crowded that the homeowner sees roaches downstairs.

"This discovery," Brenner says, "will revolutionize how pest control operators deal with infestations." Previously, these roaches were handled the way Germans and brownbandeds are—by spraying the perimeter of the home and baseboards, where domestic roaches live.

For the large roaches, "spraying kills only the small percentage of the population that wandered downstairs or inside from a tree hole," he says.

Pest control operators should set out toxic baits (like those Brenner is now developing) in the areas identified as principal habitats.

This is better for the environment than spraying chemicals in and around a home. "And the baits make roaches belly-up but don't hurt cats, dogs, and squirrels, or cockroach parasites."

Using his new tactic around infested homes in Gainesville, Brenner reduced outdoor populations of large roaches by over 95 percent. The residents happily reported seeing no more roaches inside for up to 6 months.

Whether through time, adapting to

new situations, or on an importer's ship across thousands of miles, or out of a tree hole, looking for new living space—the versatile and disgusting roach will undoubtedly keep moving. And Brenner and Patterson will be close behind.—By **Jessica Morrison,** ARS.

Richard S. Patterson and Richard J. Brenner are at the USDA-ARS Insects Affecting Man and Animals Research Laboratory, P.O. Box 14565, Gainesville, FL 32604. ■

From the Orlando Normal to Superroach

Scientists need actual roaches on which to test potential controls, be they chemical or biological. For German roaches, they have been using a colony called the Orlando normal, maintained in the Gainesville lab since the 1940's.

The average German roach living outside of captivity, meanwhile, has spent years surviving all kinds of odds and is therefore much stronger than its counterpart in the Gainesville lab. "The Orlando normal has been so pampered it doesn't represent what's out there in people's houses," Patterson says.

Something had to be done, so the scientists started looking for the most resistant roach they could find.

Coincidentally, Patterson got a call for help from the House of Representatives in Washington, DC. The problem: a German roach that resisted nearly all the chemicals pest control operators could spray on it. The only ones it didn't resist were ones in the carbamate group, poisons commonly used in household ant and roach sprays and bait trays.

So they moved a few of the roaches down to Gainesville and crossed them with a strain that resists the carbamates. The result: HRDC (for House of Representatives, Washington, DC), also known as Superroach.

"We will still screen chemicals with the Orlando normal, but then we'll use HRDC to do the final choosing. If something kills this thing, it will kill anything," Patterson says.—**J.M.**

Tim McCabe

Richard Brenner places filter material that will act as a barrier to roaches in the ridge vent atop this small-scale roof. The roof structure is used in studies to learn where roaches enter homes and how they might be kept out. (1286X1366-5)

Team Research Gets Results

Rob Flynn

The ARS cotton team (clockwise): Paul Hedin, chemist (seated); Randle McPherson, agronomist; Joe Mulrooney, entomologist; Ray Shepherd, agronomist; Barry Knight, agronomist; Jack McCarty, agronomist; Valeria Allsup, chemist; Bill Parrott, entomologist; and Johnie Jenkins, geneticist. Chemist A.C. Thompson was not present. (1286X1384-10A)

If two heads are better than one, then ten heads are even better, especially if they belong to scientists trained in different disciplines. This multidisciplinary approach to research is one of the guiding principles of the highly successful Crop Science Research Laboratory, a part of USDA's Agricultural Research Service located on the campus of Mississippi State University.

This lab is home base to three multidisciplinary teams of problem-solving scientists, whose assignment is to breed crops that resist all sorts of disasters, including drought, insects, diseases, and nematodes.

One ARS team works to breed resistant cotton, one breeds corn, and one works on forage crops, primarily clovers. Team members' backgrounds range from agronomy and plant genetics to nematology, entomology, and chemistry. All share their knowledge and experience.

"Good research teams are not created overnight," says Terry B. Kinney, Jr., ARS administrator. "The typical scientist emerges from a university with a doctorate in a single discipline, such as chemistry, biology, or agronomy."

"As a rule, such researchers have little experience in working and trading ideas with other disciplines. This narrow, single-specialty approach may contribute important information, but it won't solve many of the complex problems facing agriculture today."

Kinney points out that until 1972, the organization of his agency usually precluded forming multidisciplinary teams. "Historically," he says, "research in the U.S. Department of Agriculture was organized along disciplinary lines, with agronomists reporting to agronomists and entomologists to entomologists.

"That system had outlived its usefulness by 1972, when we reorganized along geographical lines, without regard to disciplines. Theoretically, team-building began then, but in reality, team operations have been slow and sometimes difficult to implement."

Now, 14 years after the reorganization, Johnie N. Jenkins, who is coordinator of research at this location, director of the crop science research lab, and geneticist for the cotton team, can't imagine doing research any other way.

He finds that team research is more efficient. The forage team, for example, researches pests of arrowleaf clover. Before the team approach, the pathologist would look only at diseases, the entomologist only at insect pests. But together, working out of the same field plot, the team finds important interactions between insects and disease.

They have found that pea aphids, insects that suck fluids from clover, also spread a viral disease, bean yel-

low. The disease, in turn, weakens plants and predisposes them to infection by a root-rotting fungus. The team also discovered that fields with some plants infected with fungus will suffer more rapid spread of the virus than fields without it.

The reason is that pea aphids dislike plants infected with the fungus, so they hop from plant to plant looking for a healthy one—spreading the virus more widely as they feed. Each disease alone reduces clover yields about 20 percent; together, the virus and fungus destroy a whopping 60 percent.

"We can see that there's more than just one thing going on at the same time," the forage team's pathologist Robert G. Pratt says. Armed with their new knowledge, team members will be able to plan control strategies more efficiently. They won't, for example, breed arrowleaf clover for resistance to the fungus alone and expect it to flourish; they know the aphid and virus need to be dealt with, too.

The forage team also makes good use of its animal scientist. After all, asks Jenkins, what's the point of spending years to breed a new variety of resistant clover if the cows won't eat it? With the help of the animal scientist, the team can breed resistant clover that is acceptable to the animal's taste and suited to its nutritional needs.

In retrospect, Jenkins says, past research probably would have accomplished more if teams had worked on the problems.

For example, for many years, public and private sector scientists studied the effects of chemical growth regulators on cotton. They found that some chemicals make plants shorter, more compact, and earlier blooming. One in particular, called Pix, was found useful and is still used by cotton growers. Only now is the ARS cotton team at Mississippi State asking what regulators do to the insects and diseases affecting cotton.

"Finding out how the regulators affect both the cotton plant and its pests could have been done in the same experimental plots, at the same time, if we'd had multidisciplinary teams," Jenkins points out.

Rob Flynn

Nematologist Gary Windham (left), geneticist Gary Pederson (center), and plant pathologist Mike McLaughlin evaluate clover seedlings for nematode and virus resistance. (1286X1388-28)

"Finding out how growth regulators affect both the cotton plant and its pests could have been done in the same experimental plots, at the same time, if we'd had multidisciplinary teams."

—**Johnie N. Jenkins**, ARS plant geneticist

These teams also save time and avoid errors. Corn pathologist Eugen E. Rosenkranz, who works on dwarf mosaic virus, finds it "extremely convenient" in his personal projects to have a breeder available on the team. "It's much easier and faster to have the seed and the expertise on how to grow it right here," he says. "Of course, the breeder also has the breeding and genetics experience necessary for a productive cooperative program," he continues.

The corn team wants to breed corn that resists *Aspergillus flavus,* a fungus that can produce aflatoxin, a poison and possible cancer-causing agent. Breeder Gene E. Scott grows different kinds of corn for genetic experiments. Pathologist Natale Zummo inoculates the corn with the fungus and then evaluates it for percentage of kernels infected. Next, chemist Paul A. Hedin evaluates the corn for aflatoxin concentration. Scott uses this data to select corn lines resistant to kernel infection and to develop lines with higher levels of resistance.

Because insect-damaged ears tend to have more aflatoxin, the ultimate hybrid would have resistance to ear-feeding insects as well as to fungal infection. This is where entomologist Frank M. Davis contributes his expertise—by rearing large numbers of special research strains of insects.

"When we select resistant corn lines," Jenkins says, "we need to

Tim McCabe

In studies to identify corn varieties resistant to the fall armyworm, entomologist Frank Davis (left) and geneticist Paul Williams examine damaged leaves on corn plants infested with the armyworm larvae. (0786X785-29)

know that there is no chance that the plants accidentally escaped the insects."

Uniform infestation techniques with these research strains of insects, developed for the corn team by Davis and for the cotton team by W.L. Parrott, make sure this doesn't happen.

A breeder working alone would not have the time or training to rear insects in large numbers and make sure the insects uniformly infested the plots; chalk another one up for team research.

Hedin, who works on both the corn and cotton teams, adds his knowledge of plant and insect chemistry to round out each team. In one instance, Davis and Hedin worked together to identify the multicomponent pheromone of the female southwestern corn borer.

Davis studied the insect's sexual behavior in the lab, and Hedin isolated and identified the compounds thought to lure male borers. Davis then tested each compound to see exactly which was most successful in attracting males. He determined that a precise combination of three compounds is necessary to arouse them.

Jenkins observes that a team approach can also turn research in unexpected directions. The cotton team, for example, may have come up with a new way to select cotton plants that resist pests.

Here's how it happened.

The entomologist, to help breed resistance to tobacco budworm, infested fields with larvae and watched their behavior on plants. He observed that young larvae feed mainly on the calyx crown—the rim of the green, leafy part of the cotton bud.

The agronomist and geneticists, experts on the plant itself, noted that the calyx crown is one place without many gossypol glands. They also knew that they could breed glands into this area. Gossypol is probably cotton's most important natural defense against pests. It is also toxic to some livestock.

When tobacco budworms were put on special strains of cotton that had gossypol glands in the calyx crown, the entomologist observed that they didn't feed there.

The answer to discouraging the budworms, however, was not to breed cotton with more gossypol; it would turn up in dangerous levels in cottonseed oil and cottonseed meal used for animal feed. The team decided instead that less gossypol, more widely distributed across the calyx, might best repel the insect. They set up experiments to find out.

Chemist Hedin determined how much gossypol was in each line of cotton. The team will use his data to see if only large amounts of gossypol repel larvae, or if, as they hope, less of it—in glands spread across the calyx—will do the trick. If the latter is true, they will breed cotton with many small gossypol glands.

The chemist reminded the team what he and nematologist Raymond L. Shepherd had discovered about gossypol: that it helps cotton resist root-knot nematodes. The scientists also recalled that some lines resisting bacterial blight have more gossypol. A theory emerged: gossypol and other chemicals produced by the plant are cotton's built-in "antibiotics," giving it overall resistance to insects, diseases, and nematodes.

The team hypothesized that a cotton line resisting bacteria must have the gossypol it needs to resist its other enemies—insects and nematodes. If they are right, researchers could identify lines that resist bacteria and be relatively sure they have insect and nematode resistance, too. This would take only 36 hours in the lab, compared with a minimum of 60 days of field work required to test plants with actual pests.

A teamwork success came to the corn researchers, too. The breeder, entomologist, and pathologist bred and

Rob Flymn

Forage team members, Bob Pratt (left), a plant pathologist, and Dennis Rowe, a geneticist, examine crimson clover seedlings for resistance to fusarium wilt. (1286X1390-4A)

Rob Flymn

Agronomist Jack McCarty (left) and entomologist Bill Parrott put tobacco budworms on various cotton genetic types to determine how fast the worms grow and the amount of damage done to plants. (1286X1385-5A)

released new corn lines that resist two serious pests of late-planted corn—fall armyworm and southern corn rust.

The team's agronomist, Joe O. Sanford, saw their potential in helping him develop a new double-cropping system. Previously, he had found that commercial corn serves only as a first crop, grown in late spring. Planting it as a second crop in June didn't work; the fall armyworm and southern rust had emerged by then to destroy it. So he asked the breeder to use the resistant lines to produce experimental hybrids with resistance. Sanford tested them and although they are somewhat lower yielding than commercial hybrids, they do allow corn to be planted in a double-cropping system after wheat. This practice can, of course, increase a farmer's overall income.

Certainly, the ARS teams at Mississippi State have had many successes. So far, the oldest team, the cotton group, has released lines of cotton that resist boll weevils, tobacco budworms, root-knot nematodes, and bacterial blight.

The corn group has released corn lines that resist fall armyworm, southwestern corn borer, southern rust, maize dwarf mosaic virus, maize chlorotic dwarf virus, and downy mildew.

The newest group, researching forages, has found resistance to viruses in white clover and tolerance to winter injury in a new annual clover.

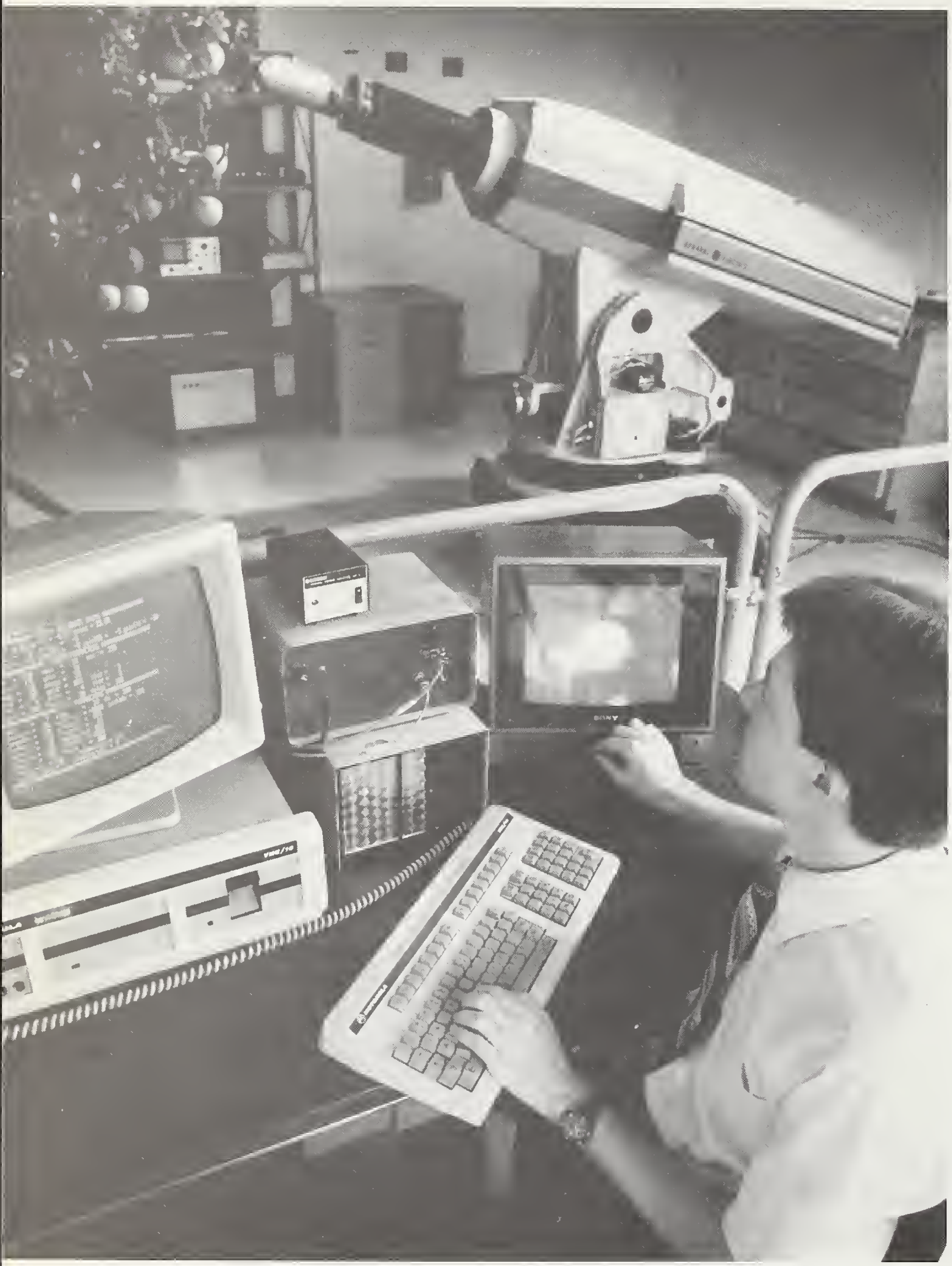
Each of these findings ultimately contributes to a larger research objective—to understand the mechanisms of plant resistance and, with that knowledge, to breed crops that withstand all sorts of pests and stresses.

As Jenkins says, "Individually, we are experts in chemistry, agronomy, or another discipline. But by combining our talents, the teams have become experts in plant resistance—something we never were before."—By **Jessica Morrison,** ARS. **Hubert Kelley,** ARS, contributed to this article.

Scientists mentioned in this article are at the USDA-ARS Crop Science Research Laboratory, P.O. Drawer 5367, Mississippi State, MS 39762. ■

Color TV Best for Robot Fruit Pickers

Tim McCabe



Tim McCabe

Above: At the University of Florida's Agricultural Robotics Lab, ARS engineer David Slaughter watches video monitors during a laboratory test of the fruit-picking robot. Under computer control, the robot's arm reaches for a plastic orange on an imitation tree. (1286X1359-27)

Right: David Slaughter adjusts an imitation orange for tests with an experimental fruit-picking robot. The robot uses a color video camera to "see" the orange. (1286X1357-23)

Ever reach for a fluffy cloud because you thought it was a juicy orange?

Probably not—unless you happen to be a robot that sees only in black and white and you're in control of a fully automated harvester making its way along a row of orange trees.

"In that case," says David C. Slaughter, an engineer with USDA's Agricultural Research Service, "a small cloud might very well appear the same as an orange, especially if the orange were in direct sunlight, because the two of them would be equally bright in the eye of the robot harvester."

Color television, according to Slaughter, will solve the problem.

Slaughter has been investigating ways in which "machine vision" (the term for TV-like image-recognition capabilities in automated machinery) could be used by fully automated fruit harvesters.

Although such harvesters have yet to be built, they are on the drawing boards, and Slaughter has misgivings about plans to equip them with black-and-white imaging systems.

"Black-and-white systems can measure the size, shape, or brightness of an object," he says, "but that's not going to help the automated harvesting of fruit, no matter how accurate the measurements are."

Identifying an orange by its size or shape requires constant analysis and comparison of images, explains Slaughter. Even with high-speed computers on board, it's too long a process. To be profitable, an automated harvester has to move rapidly.

What about image brightness?

Slaughter agrees that black-and-white measurements of brightness do provide, in theory, a way to rapidly distinguish fruit from surrounding branches and leaves.

"But that's in theory only," he says. "In real orchards, sunlight and shadow can cause a lot of confusion. An orange in sunlight can read the same as a cloud, and an orange in the shade can appear as dull as a leaf in the sun."

Color television, on the other hand, can give quick and accurate readings that in no way depend on size, shape, or brightness. In fact, color is the only thing that matters.

"Our tests show that the color of an orange is enough for a harvester to go on," says Slaughter. "No other criteria are needed. The machine can readily recognize the right color and pick accordingly."

Working with engineers at the University of Florida's Agricultural Robotics Laboratory, Slaughter attached a color video camera to a mechanical arm like the kind being planned for robotic harvesters. The arm's movement was controlled by a computer programmed to locate orange colors amid images transmitted by the camera. A plastic tree, complete with plastic leaves and oranges, served as a test subject.

"Time after time," says Slaughter, "the color vision setup steered the arm past branches and leaves and right up to the fruit."

Of course, plastic targets are hardly the same as real trees and oranges that might have substantial variations in color. With that in mind, the engineers took the camera used on the robotic arm out to a nearby orchard and made video tapes of the fruit and foliage from the same positions the arm would be in.

"Back at the lab," says Slaughter, "our computer was able to scan the pictures from the orchard and pick out oranges every bit as well as it did with the plastic tree. But we still plan to test the whole thing, arm and all, in real orchards this winter."

Slaughter and his colleagues use a video camera with a charged-coupled imaging device (CCD), a thin square of optically sensitive material about the size of a postage stamp. It converts light into electrical charges corresponding to a picture. It is used in place of bulky photo tubes in many home video cameras, especially the smaller ones, and is essential to the effectiveness of a robotic fruit harvester.

"A CCD won't be ruined as would a regular photo tube if the camera should face into the sun," says Slaughter.

There is one drawback to CCD's: Cameras using them need more light.

"That is a problem," acknowledges Slaughter, "but we don't expect it to last forever. Right now, our color vision system won't work well in low light, as at early dawn or dusk. But CCD technology is improving and camera lenses are getting faster. We're also considering the use of artificial light."

At present, the robotic system will operate only within a range of colors associated with harvest-ready oranges. Programming it to select other colors—which would mean other kinds of fruit—is no problem, according to Slaughter, provided the color isn't leaf green.

"Lemons we can find," he says, "limes we cannot."—By **Steve Miller,** ARS. Photography by **Tim McCabe.**

David C. Slaughter is in the USDA-ARS Insect Attractants, Behavior, and Basic Biology Research Laboratory, P.O. Box 14565, Gainesville, FL 32604. ■

Trichinosis Research Goes Commercial

Three private firms have obtained licenses to use U.S. Department of Agriculture research on the detection of trichinosis in pigs. Trichinosis, a disease caused by a parasitic worm, doesn't affect humans if pork is properly cooked.

The Agricultural Research Service licensed two firms to use a special line of antibody-producing cells developed by H. Ray Gamble and K. Darwin Murrell of the Beltsville (Maryland) Agricultural Research Center. The firms are Agritech Systems, Inc., of Portland, ME, and Difco Research and Development Center of Ann Arbor, MI.

Idetek, Inc., of San Bruno, CA, received a license to sell its own version of a new, highly accurate blood test developed by Gamble and Murrell. USDA's Animal and Plant Health Inspection Service issued this license.

The ARS test and its Idetek cousin use an extract from trichina worms grown in culture. A pig's blood sample is added to this reagent, and after several intermediate steps, a yellow color develops if antibodies to the worm are present—meaning the pig is infected.

At present, the new test can be used only in field studies, says Murrell, who heads the Helminthic Diseases Laboratory, but slaughterhouses nationwide may one day use the test if approval is granted by USDA's Food Safety and Inspection Service. This year, he added, the state of Illinois used the test to identify and cull infected swine from herds.

Murrell's laboratory, under cooperative research agreements, supplied reagents developed for the new test to Idetek, Integrated Genetics, Inc., of Framingham, MA, and Abbott Laboratories, Inc., of North Chicago, IL.

Further work with the laboratory-grown cell line—called a monoclonal antibody line—could lead to a standard, purified reagent for the Idetek test and possibly other trichinosis tests. The cell line is being considered for patent protection.

Only 32 cases of human trichinosis were reported in the United States last year, Gamble says, but trichinosis can go undiagnosed because the symptoms are usually vague and flu-like.

The Agricultural Research Service has established that cooking pork to an internal temperature of 171 degrees Fahrenheit eliminates any chance of getting the disease.—By **Vince Mazzola,** ARS.

H. Ray Gamble and K. Darwin Murrell are in the USDA-ARS Helminthic Diseases Laboratory, Beltsville Agricultural Research Center—East, Beltsville, MD 20705. ■

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PATENTS

Making Fabric More Colorful

Cotton, rayon, and linen can now be treated to accept almost all major classes of dyes. Without treatment, cotton and other cellulosic fibers don't accept acid dyes, which are used for dyeing wool and some synthetic fibers, or insoluble dyes in an aqueous dispersion (disperse dyes), also used for synthetic fibers.

The cellulosic fibers are soaked in a solution of aqueous alkali metal hydroxide and then treated with a thioarylsulfonium salt solution to make the fibers receptive to the dyes. These fibers can then be blended with synthetic fibers such as polyester or with natural fibers such as wool.

Dipping such fabric blends into a bath with two very different types of dyes produces a bicolored fabric, with each fiber type accepting a different dye. Or, if desired, they can be treated with one dye for a uniform shade.

Previously, natural fibers were treated to accept one class of dye, such as acid or disperse dye. Now they can be treated to accept two or more dye classes in one bath. Not only are the number of dyeing steps reduced, but the new treatment makes the fabric more colorfast than could be obtained with untreated material.

Tests show that a treated cotton can be dyed a deeper shade than cotton fabric either untreated or treated with caustic soda (mercerized).

The treated fabric allows for a versatility of dyeing not attainable with unmodified cellulose blends, accepting many dyes under a wider range of pH conditions than is possible for unmodified fibers.

For technical information, contact Tyrone L. Vigo or Eugene J. Blanchard, USDA-ARS Southern Research Center, P.O. Box 19687, New Orleans, LA 70179. *Patent Application Serial No. 903,173, "Arylsulfonium Cellulosic Fibers Substantive to Many Dye Classes."* ■

Helping Roundworms Swallow Nematicides

Nematicides used to treat roundworms in livestock tend to paralyze the worms' throat muscles, making it difficult for them to swallow a fatal dose of the poison.

Certain amine chemicals, such as dopamine, serotonin, and histamine, counteract this.

Preliminary experiments with mice show that an oral dose of amines mixed with nematicide increased both the amount of toxin eaten by nematodes and the number of nematodes killed.

Other experiments show that histamine at 0.025 millimole caused ruminant nematodes (taken from goats) to eat two to nine times more nematicide than usual. The actual amount of amine necessary may vary depending on the nematode species, host animal, type of nematicide, and amine used.

Because the worms eat more nematicide, amines could allow for substantial reductions in doses and possible residues in meat while still killing the parasites.

Unfortunately, all the amines tested to date have side effects on the host animal that would make them unsuitable for commercial use. The search is on for biological amines or synthetic counterparts that will work safely in livestock, particularly cattle, pigs, goats, and sheep where roundworms cause economic losses.

For technical information, contact Leon W. Bone at the USDA-ARS Animal Parasite Research Laboratory, P.O. Box 952, Auburn, AL 36831-0952. *Patent Application Serial No. 905,209, "Enhancing Anthelmintic Uptake in Nematodes by Phagostimulants."* ■

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